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Heritability Estimates of Milk Production with Different Numbers of Records per Sire by Herd Subclass

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Abstract

The first-lactation milk records of 20,850 artificially sired Holstein cows and their dams were analyzed by a sire-by-herd, variance components model to determine if unequal numbers of records in the filled subclasses had any effect on the paternal half-sib correlation or the daughter-dam regression. The variance components were estimated with the number per subclass held constant at 1, 2, 3, 4, or 5. The records were also analyzed as deviations from herd-mate averages. The analysis of deviations with one observation per subclass gave the highest heritability estimate from daughter-dam regression, .40, and the lowest from paternal half-sib correlation, .23. Analyses of deviations with two, three, four, or five observations per subclass gave approximately the same estimates of heritability from both daughter-dam regression (.31, .32, .29, and .23) and paternal half-sib correlation (.32, .31, .27, and .36).

The difference in heritability estimates from daughter-dam regression (.44) and paternal half-sib correlation (.25) reported by Bradford and Van Vleck (2) has led to several studies of the New York DHIA milk production data to explain this difference (5-7). The present study was made to determine if unequal numbers of observations in the filled subclasses of a sire-by-herd, two-way classification model may affect the paternal half-sib correlation or the daughter-dam regression.

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Materials and Methods

The data were the same as those of Van Vleck and Bradford (6), although only first-lactation records were used. Briefly, these were first-lactation (305-day, 2×, M.E.) milk records of artificially sired Holstein daughters and their dams. The records were also analyzed as deviations from herd-mate averages (3). The statistical model included sire, herd, sire-by-herd interaction, and residual effects, all considered as random variables. Components of variance associated with these effects were estimated by Method I of Henderson (4), for all data, and also for data when there were one, two, three, four, or five observations in each sire by herd subclass. The interaction component was eliminated from the model and the variance components re-estimated to compare with the estimates from the analysis by the full model. Heritability was estimated from the sire components on a within-herd basis for each analysis. Comparable estimates from daughter-dam regression were computed from the residual components of variance and covariance.

Results and Discussion

The number of records, herds, sires, and subclasses for each of the analyses are given in Table 1. The daughter and dam means of deviations and mature equivalent records are also shown in Table 1. The means indicate that the daughter records are more selected, the greater the number of records required per subclass.

TABLE 1

Number of records, sires, and herds and daughter and dam means

No. per subclass	No. Records	No. Herds	No. Sires	No. Sub-classes	Averages (lb ÷ 10) Daughter Dev.	Daughter M.E.	Dam Dev.	Dam M.E.
⩾1	20,850	2,429	317	14,861	.3	1346.6	36.3	1303.0
1	14,861	2,429	317	14,861	−4.4	1327.6	37.8	1293.7
2	6,516	1,158	220	3,258	5.8	1364.4	35.0	1308.8
3	3,501	594	126	1,167	11.9	1391.2	33.4	1325.0
4	2,108	334	84	527	31.2	1425.0	37.2	1342.9
5	1,470	219	63	294	30.8	1439.2	36.4	1356.1

The means of the corresponding dams do not follow the same pattern as the means for the daughters.

Results of the analyses of variance components are listed in Table 2. There appears to be a slight tendency for the total variance to be somewhat less for data with three or four observations per subclass than for over-all data or for data with five observations per subclass.

Neither the herd nor the sire-by-herd components of variance appear to change with numbers per subclass for the records expressed as deviations. The herd component for mature equivalent records appears to decrease as the number per subclass increases. This may be expected, since only larger herds could qualify several daughters per subclass. The larger herds may be more similar to each other than to smaller herds. This would not affect the herd component for deviations very much, since that component is mostly removed by use of deviations from herd-mate averages. Correspondingly, the residual component increases in relative importance for the mature equivalent records as number per subclass increases.

The same general pattern for the residual component prevails for the reduced model as for the full model. Most of the interaction component appears to go into the residual component, although some goes to the herd component and a slight amount to the sire component.

Results pertaining to the critical question of the effect on heritability estimates of numbers per subclass are shown in Table 3. Considering deviations first, there appears to be little differ-

TABLE 2

Estimates of variance components for analyses with different numbers of records per subclass

No. per subclass	Deviations					Mature equivalent				
	Sire	Herd	S × H	Error	Total	Sire	Herd	S × H	Error	Total
	(%)				$(lb/10)^2$	(%)				$(lb/10)^2$
Full model										
⩾1	6.0	4.5	4.6	84.9	57,577	10.8	26.5	1.3	61.4	78,465
1	5.4	5.0	89.6	......	57,286	9.2	27.0	63.8	......	77,740
2	7.6	4.7	5.3	82.4	58,350	11.4	24.9	4.3	59.5	77,818
3	7.6	2.4	5.0	85.0	56,524	13.1	23.4	1.2	62.3	75,250
4	6.6	3.5	5.5	84.4	56,971	9.7	22.2	3.8	64.3	73,068
5	8.4	6.4	4.5	80.7	60,919	10.7	22.4	1.4	65.4	76,054
Reduced model										
⩾1	6.0	4.8	....	89.2	57,577	10.8	26.6	....	62.6	78,465
1	5.4	5.0	....	89.6	57,286	9.2	27.0	....	63.8	77,740
2	7.7	5.8	....	86.5	58,353	11.5	25.8	....	62.7	77,822
3	7.8	4.4	....	87.8	56,350	13.2	23.9	....	62.9	75,252
4	7.0	6.4	....	86.6	56,982	10.0	24.2	....	65.8	73,078
5	8.6	9.4	....	82.0	60,930	10.8	23.4	....	65.8	76,059

TABLE 3

Heritability estimates from daughter-dam regression and paternal half-sib correlation

No. per subclass	Daughter dam			Paternal half-sib			
	Deviations	M.E.	S.E.[a]	Deviations	S.E.[a]	M.E.	S.E.[a]
Full model							
⩾1	.30	.32	.03	.25	.02	.59	.04
1	.40	.36	.02	.23	.02	.50	.03
2	.31	.33	.04	.32	.04	.60	.05
3	.32	.36	.05	.31	.05	.68	.07
4	.29	.32	.06	.27	.06	.50	.08
5	.23	.22	.07	.36	.08	.55	.10
Reduced model							
⩾1	.37	.32	.02	.24	.02	.59	.04
1	.40	.36	.02	.23	.02	.50	.03
2	.28	.28	.03	.33	.04	.62	.05
3	.31	.34	.04	.33	.05	.69	.07
4	.30	.32	.05	.30	.06	.53	.08
5	.24	.21	.06	.38	.08	.56	.10

[a] Approximate standard errors of heritability estimates.

ence in daughter-dam and paternal half-sib estimates for analyses having subclasses with equal numbers per subclass of two to five. There is a major difference between daughter-dam and paternal half-sib estimates for the analysis with only one observation per subclass. Most of the data are of that type—only one daughter per herd-sire group, which makes the estimates from all the data very closely resemble those from the analysis with one observation per subclass. The daughter-dam estimates for one observation per subclass are based on the sire-by-herd components of variance and covariance, since the residual and sire by herd components are completely confounded.

The higher estimates from paternal half-sib correlation for data with more than one observation per subclass may be due to positive environmental covariance among paternal half-sibs in the same herds (1). Possible reasons for the smaller daughter-dam estimates for data with more than one observation per subclass do not seem apparent.

The analyses of mature equivalent records yielded daughter-dam regressions similar to those from deviations. The paternal half-sib estimates, however, appeared to be considerably inflated. Van Vleck and Bradford (6) suggested that this upward bias is probably due to confounding between when the sires entered service and year-season effects not included in the statistical model for this study. Positive environmental covariance could, also, account for some upward bias, since the estimate from only one observation per subclass is smaller than the other estimates.

Conclusions

The number of observations per subclass apparently has some effect on estimates of heritability. The analysis with one observation per subclass for deviations gave the highest estimate of heritability from daughter-dam regression and the lowest estimate from the paternal half-sib correlation. Analyses with more than one observation per subclass yielded approximately the same estimates of heritability from both daughter-dam regression and paternal half-sib correlation. In the latter case, positive environmental covariance amounting to .01 to .02 of within-herd variance could account for the increase in the paternal half-sib estimate. Why the daughter-dam regression should be reduced with more than one observation per subclass is not clear.

Although some clues as to the difference between heritability estimates from daughter-dam regression and paternal half-sib correlation were formed in this study, the difference has still not been satisfactorily explained.

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